



# Remote-sensing data analysis

## *Physics-based modeling and retrieval*

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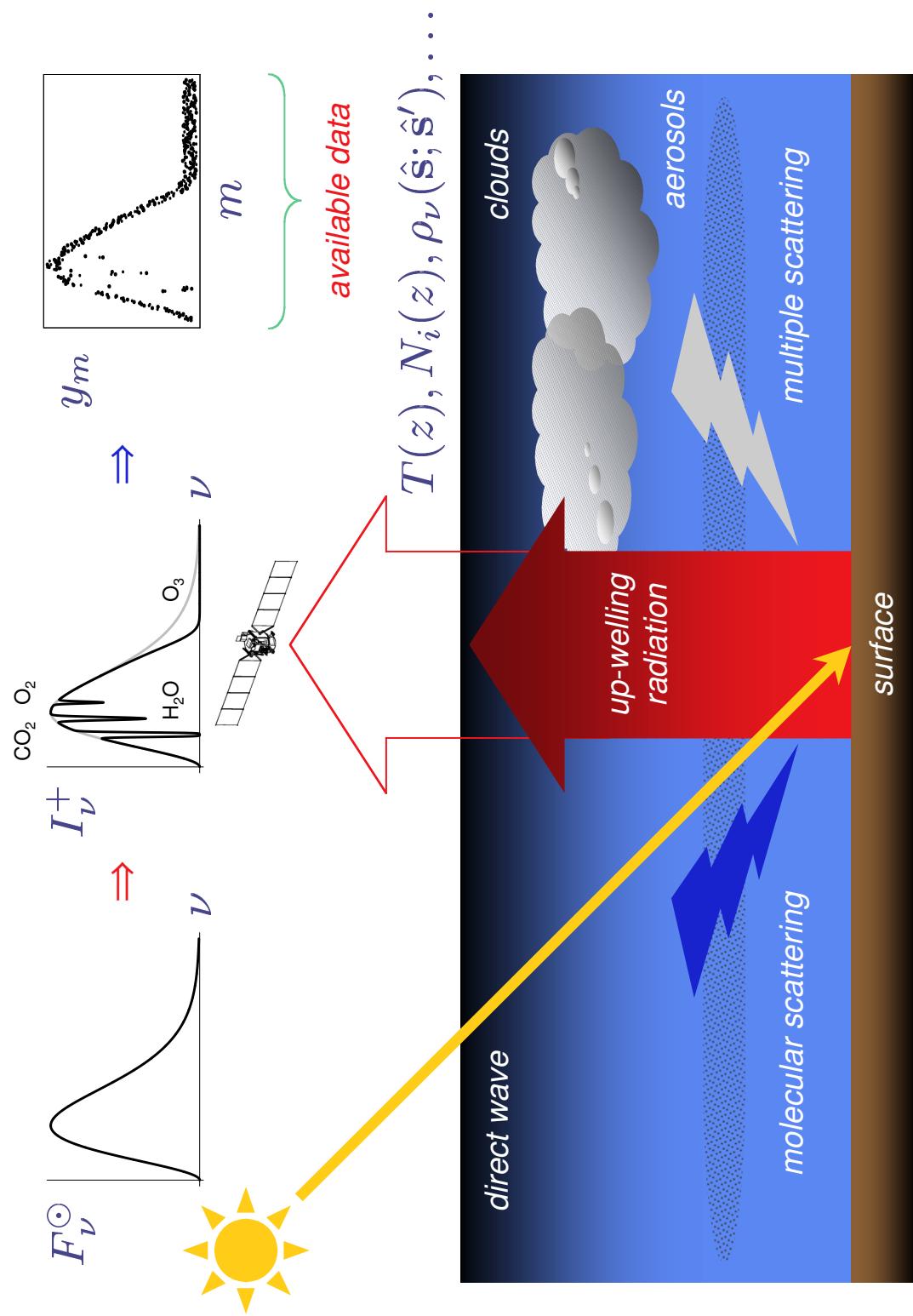
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# Basic premise



- Scientific data are generated by observing phenomena that obey the laws of physics  
⇒ incorporating these laws into data analysis will lead to
  - more accurate modeling and prediction
  - smarter instruments and observations
  - a deeper understanding
- moderately complex systems:  
first-principles modeling possible
- highly complex systems:  
phenomenological modeling + machine learning  
(i.e., don't give up!)

# Typical remote-sensing scenario



# New data-analysis framework



- Rigorous forward modeling of atmosphere & surface
  - discrete-ordinates radiative-transfer theory
  - HITRAN database for molecular absorption
  - Mie scattering for cloud and aerosol particles
  - parametric models for surface spectral BRDF
  - instrument angular and spectral response functions
  - forward-model derivatives with respect to unknown (atmospheric, surface, *instrument*) parameters
- Bayesian retrieval of medium properties from data
  - Gauss–Newton optimization w/ Levenberg–Marquardt
  - multi-sensor fusion with a single forward model

# Extensions and applications



- Generalize to
  - vectorial radiative transfer for polarimetric data
  - assimilation of dynamical (spatio-temporal) data
  - other regions (IR,  $\mu$ wave), active sources (radar, lidar)
- Apply to (Earth, Moon, Mars, distant planets, etc.)
  - inferring atmospheric and surface composition
  - learning spatio-temporal atmospheric dynamics
  - learning “effective” models of dynamical systems
  - cause-effect analysis; dynamical forecasting
  - design of intelligent and autonomous sensors
  - sensitivity analysis for new instrument design